The Use of NEMS in Energy Policy Analysis: An Annotated Bibliography

Jeff Hubbs
Graduate Research Assistant
Climate and Energy Policy Laboratory (CEPL)
Georgia Institute of Technology
School of Public Policy
jeffrey.hubbs@gmail.com

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Revision History

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1.1	2/26/2013	Acknowledgements addition
1.2	01/24/14	Contact information change

Introduction

This document forms an annotated bibliography of published works from 2000 to the present related to the use of the US Energy Information Administration's National Energy Modeling System (NEMS).

Literature searches were performed using the Georgia Tech Library's online facilities and the University System of Georgia's GALILEO library portal. Additional works were obtained through CEPL's own researchers as well as CEPL's network of contacts in academia and government.

The works are listed here alphabetically by lead author (or organization where there are no authors listed) and are divided up into four lists based on characterizations defined as follows:

- *Methods* – describes the methodologies or assumptions that go into NEMS
- *Findings* – predictive findings based on NEMS output
- *Feedback* – feedback on NEMS' predictive fidelity
- *Comparative* – comparing the output of other modeling systems with that of NEMS or mention NEMS by way of comparison

The citation for each work is followed by the work's abstract or the first paragraph of its introduction absent an abstract.

Mendeley Desktop (http://mendeley.com) was used to manage and export the citations and store their corresponding document files. This document was produced in LibreOffice (http://libreoffice.org).

Methods

Baek, Y. (2011). *Responsiveness of residential electricity demand to changes in price, information, and policy*. Atlanta, Ga. : Georgia Institute of Technology, 2011. Retrieved from http://hdl.handle.net/1853/39581

> This study analyzes consumers' behavioral responsiveness to changes in price and policy regarding residential electricity consumption, using a hybrid method of econometric analyses and energy market simulations with the National Energy Modeling System (NEMS). First, this study estimates price elasticities of residential electricity demand with the most recent Residential Energy Consumption Survey (RECS) data, collected in 2005, employing a conventional econometric model and a discrete/continuous choice model. Prior to the NEMS experiments with price shocks and consumers' behavioral features, this study uses NEMS to examine how energy policies would affect changes in retail electricity price in the future. When climate policies are implemented nationally, electricity prices are estimated to increase by 17% in 2030 with a carbon cap and trade initiatives and by 4% with Renewable Electricity Standards (RES). The short-run elasticity of demand estimated from the 2005 RECS is found to be in a range of -0.81 ~ -0.66, which is more elastic than the current NEMS assumption of -0.15. The 2005 RECS dataset details information about American households' energy consumption. This rich source of micro-level data complements the existing econometric analysis based on time series data.

Brown, S. (2012). Agency Information Collection Extension. *Federal Register*, *77*(228), 70741–70742. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=84346122&site=eds-live&scope=site

> The article focuses on a notice issued by the U.S. Energy Information Administration (EIA) regarding solicitation of comments on the proposed information collection (IC) submitted to the U.S. Office of Management and Budget (OMB). IC entitled "Annual Survey of Alternative Fueled Vehicles (AFVs)" collects information on the AFVs available and improves the explanatory power of the National Energy Modeling System (NEMS) Transportation Demand Model for AFV types and characteristics.

Gabriel, Steven A, Kydes, A. S., & Whitman, P. (2001). The National Energy Modeling System: A Large-Scale Energy-Economic Equilibrium Model. *Operations Research*, *49*(1), 14. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4146537&site=eds-live&scope=site

> The National Energy Modeling System (NEMS) is a large-scale mathematical model that computes equilibrium fuel prices and quantities in the U.S. energy sector and is currently in use at the U.S. Department of Energy (DOE). At present, to generate these equilibrium values, NEMS iteratively solves a sequence of linear programs and nonlinear equations. This is a nonlinear Gauss-Seidel approach to arrive at estimates of

market equilibrium fuel prices and quantities. In this paper, we present existence and uniqueness results for NEMS-type models based on a nonlinear complementarity/variational inequality problem format. Also, we document mathematically, for the first time, how the inputs and the outputs for each NEMS module link together.

Gumerman, E. Z., LaCommare, K. H., & Marnay, C. (2002). *New Method and Reporting of Uncertainty in LBNL National Energy Modeling System Runs*. eScholarship, University of California 2002-10-01. Retrieved from http://www.escholarship.org/uc/item/2pv9r6c2

This report describes LBNL's approach for assessing uncertainty in any National Energy Modeling System (NEMS)-related analysis. Based on years of experience using LBNL-NEMS for various analyses, LBNL developed an alternative approach that aims to provide a simple yet comprehensive perspective of how the results behave under a given set of what we believe to be some of the issues important to large-scale energy modeling. This project has established a standard set of eight sensitivity cases that can be run overnight and are highly likely to produce stable and interesting results. The goal was to establish a limited number of interesting sensitivity cases that would routinely produce adjunct results to LBNL-NEMS reporting that will be of value to our readers. These cases will be routinely reported together with future LBNL-NEMS results in the form of a standard output table. As an example, this work uses a Government Performance and Results Act (GPRA) analysis run as the baseline, but the goal is to establish a standardized set of cases that would change little over time and be applicable to other analyses in addition to GPRA. The approach developed here cannot serve as a substitute for a sensitivity analysis tailored to the question at hand, but it can provide a fast review of some areas that have proven to be of interest in the past.

Haq, Z., & Easterly, J. (2006). Agricultural residue availability in the United States. *Applied Biochemistry and Biotechnology*, *129*(1-3), 3. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edo&AN=ejs12749406&site=eds-live&scope=site

The National Energy Modeling System (NEMS) is used by the Energy Information Administration (EIA) to forecast US energy production, consumption, and price trends for a 25-yr-time horizon. Biomass is one of the technologies within NEMS, which plays a key role in several scenarios. An endogenously determined biomass supply schedule is used to derive the price-quantity relationship of biomass. There are four components to the NEMS biomass supply schedule including: agricultural residues, energy crops, forestry residues, and urban wood waste/mill residues. The EIA'S Annual Energy Outlook 2005 includes updated estimates of the agricultural residue portion of the biomass supply schedule. The changes from previous agricultural residue supply estimates include: revised assumptions concerning corn stover and wheat straw residue availabilities, inclusion of non-corn and non-wheat agricultural residues (such as barley, rice straw, and sugarcane bagasse), and the implementation of assumptions concerning increases in no-till farming. This article will discuss the impact of these changes on the supply schedule.

Hobbs, M., Mellish, M., Murphy, F. H., Newcombe, R., Sanders, R., & Whitman, P. (2001). Rebuilding the Coal Model in the Energy Information Administration's National Energy Modeling System. *Interfaces*, *31*(5), 24–42. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5719826&site=eds-live&scope=site

The Energy Information Administration uses the National Energy Modeling System (NEMS) to forecast prices and quantities in energy markets. The coal model that the Energy Information Administration first used in NEMS contributed to convergence problems in NEMS because of its design. Furthermore, because the coal model could not be modified efficiently to incorporate the new sulfur dioxide market created by the Clean Air Act Amendments of 1990, we had to build a new model. Building the new model also allowed us to incorporate improved knowledge about coal resources and other aspects of coal markets, further improving the quality of the forecasts.

LaCommare, K. H., Edwards, J. L., & Marnay, C. (2003). *Distributed generation capabilities of the national energy modeling system*. eScholarship, University of California 2003-01-01. Retrieved from http://www.escholarship.org/uc/item/5ck4b4ps

This report describes Berkeley Lab's exploration of how the National Energy Modeling System (NEMS) models distributed generation (DG) and presents possible approaches for improving how DG is modeled. The on-site electric generation capability has been available since the AEO2000 version of NEMS. Berkeley Lab has previously completed research on distributed energy resources (DER) adoption at individual sites and has developed a DER Customer Adoption Model called DER-CAM. Given interest in this area, Berkeley Lab set out to understand how NEMS models small-scale on-site generation to assess how adequately DG is treated in NEMS, and to propose improvements or alternatives. The goal is to determine how well NEMS models the factors influencing DG adoption and to consider alternatives to the current approach.

Most small-scale DG adoption takes place in the residential and commercial modules of NEMS. Investment in DG ultimately offsets purchases of electricity, which also eliminates the losses associated with transmission and distribution (T&D). If the DG technology that is chosen is photovoltaics (PV), NEMS assumes renewable energy consumption replaces the energy input to electric generators. If the DG technology is fuel consuming, consumption of fuel in the electric utility sector is replaced by residential or commercial fuel consumption. The waste heat generated from thermal technologies can be used to offset the water heating and space heating energy uses, but there is no thermally activated cooling capability.

This study consists of a review of model documentation and a paper by EIA staff, a series of sensitivity runs performed by Berkeley Lab that exercise selected DG parameters in the AEO2002 version of NEMS, and a scoping effort of possible enhancements and alternatives to NEMS current DG capabilities. In general, the treatment of DG in NEMS is rudimentary. The penetration of DG is determined by an economic cash-flow analysis that determines adoption based on the number of years to a positive cash flow. Some important technologies, e.g. thermally activated cooling, are absent, and ceilings on DG adoption are determined by somewhat arbitrary caps on the number of buildings that can adopt DG. These caps are particularly severe for existing buildings, where the maximum penetration for any one technology is 0.25%. On the other hand, competition among technologies is not fully considered, and this may result in double-counting for certain applications. A series of sensitivity runs show greater penetration with net metering enhancements and aggressive tax credits and a more limited response to lowered DG technology costs.

Discussion of alternatives to the current code is presented in Section 4. Alternatives or improvements to how DG is modeled in NEMS cover three basic areas: expanding on the existing total market for DG both by changing existing parameters in NEMS and by adding new capabilities, such as for missing technologies; enhancing the cash flow analysis but incorporating aspects of DG economics that are not currently represented, e.g. complex tariffs; and using an external geographic information system (GIS) driven analysis that can better and more intuitively identify niche markets.

LaCommare, K. H., Edwards, J. L., Gumerman, E., & Marnay, C. (2005). *Distributed Generation Potential of the U.S. Commercial Sector*. eScholarship, University of California 2005-06-01. Retrieved from http://www.escholarship.org/uc/item/24f1p27f

Small-scale (100 kW-5 MW) on-site distributed generation (DG) economically driven by combined heat and power (CHP) applications and, in some cases, reliability concerns will likely emerge as a common feature of commercial building energy systems in developed countries over the next two decades. In the U.S., private and public expectations for this technology are heavily influenced by forecasts published by the Energy Information Administration (EIA), most notably the Annual Energy Outlook (AEO). EIA's forecasts are typically made using the National Energy Modeling System (NEMS), which has a forecasting module that predicts the penetration of several possible commercial building DG technologies over the period 2005-2025. Annual penetration is forecast by estimating the payback period for each technology, for each of a limited number of representative building types, for each of nine regions. This process results in an AEO2004 forecast deployment of about a total 3 GW of DG electrical generating capacity by 2025, which is only 0.25 percent of total forecast U.S. capacity. Analyses conducted using both the AEO2003 and AEO2004 versions of NEMS changes the baseline costs and performance characteristics of DG to reflect a world without U.S. Department of Energy (DOE) research into several thermal DG technologies, which is then compared to a case with enhanced technology representative of the successful achievement of DOE research goals. The net difference in 2025 DG penetration is dramatic using the AEO2003 version of NEMS, but much smaller in the AEO2004 version. The significance and validity of these contradictory results are discussed, and possibilities for improving estimates of commercial U.S. DG potential are explored.

US Energy Information Administration. (2009). EIA - The National Energy Modeling System: An Overview 2009. Retrieved January 26, 2013, from http://www.eia.gov/oiaf/aeo/overview/index.html

The National Energy Modeling System (NEMS) is a computer-based, energy-economy modeling system of U.S. through 2030. NEMS projects the production, imports, conversion, consumption, and prices of energy, subject to assumptions on macroeconomic and financial factors, world energy markets, resource availability and costs, behavioral and technological choice criteria, cost and performance characteristics of energy technologies, and demographics. NEMS was designed and implemented by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE).

The National Energy Modeling System: An Overview 2009 provides an overview of the structure and methodology of NEMS and each of its components. This chapter provides a description of the design and objectives of the system, followed by a chapter on the overall modeling structure and solution algorithm. The remainder of the report summarizes the methodology and scope of the component modules of NEMS. The model descriptions are intended for readers familiar with terminology from economic, operations research, and energy modeling. More detailed model documentation reports for all the NEMS modules are also available from EIA (Appendix, “Bibliography”).

Findings

Brown, M A, & Baek, Y. (2010). The forest products industry at an energy/climate crossroads. *Energy Policy*, *38*(12), 7665–7675. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=inh&AN=11969682&site=eds-live&scope=site

> Transformational energy and climate policies are being debated worldwide that could have significant impact upon the future of the forest products industry. Because woody biomass can produce alternative transportation fuels, low-carbon electricity, and numerous other “green” products in addition to traditional paper and lumber commodities, the future use of forest resources is highly uncertain. Using the National Energy Modeling System (NEMS), this paper assesses the future of the forest products industry under three possible U.S. policy scenarios: (1) a national renewable electricity standard, (2) a national policy of carbon constraints, and (3) incentives for industrial energy efficiency. In addition, we discuss how these policy scenarios might interface with the recently strengthened U.S. renewable fuels standards. The principal focus is on how forest products including residues might be utilized under different policy scenarios, and what such market shifts might mean for electricity and biomass prices, as well as energy consumption and carbon emissions. The results underscore the value of incentivizing energy efficiency in a portfolio of energy and climate policies in order to moderate electricity and biomass price escalation while strengthening energy security and reducing CO2 emissions.

Brown, M. A., & Sun, X. (2012). Making Buildings Part of the Climate Solution by Overcoming Information Gaps through Benchmarking. Working Paper #72. Atlanta, GA. Retrieved from http://spp.gatech.edu/faculty/workingpapers/wp72.pdf

> This paper focuses on the impact of benchmarking the energy performance of U.S. commercial buildings by requiring utilities to submit energy data to a uniform database accessible to building owners and tenants. Understanding how a commercial building uses energy has many benefits; in particular, it helps building owners and tenants focus on poor-performing buildings and subsystems, and enables high- performing buildings to participate in various certification programs that can lead to higher occupancy rates, rents, and property values. Through analysis chiefly utilizing the Georgia Tech version of the National Energy Modeling System (GT-NEMS), updating input discount rates and the impact of benchmarking shows a reduction in energy consumption of 5.6% in 2035 relative to the Reference case projection of the Annual Energy Outlook 2011. It is estimated that the benefits of a national benchmarking policy would outweigh the costs, both to the private sector and society broadly. However, its geographical impact would vary substantially, with the South Atlantic and New England regions benefiting the most. By reducing the discount rates used to evaluate energy-efficiency investments, benchmarking would increase the purchase of energy-efficient equipment thereby reducing energy bills, CO2 emissions, and conventional air pollution.

Brown, M. A., & Wang, Y. (2013). *Estimating the Energy-Efficiency Potential in the Eastern Interconnection*. Atlanta, GA. Retrieved from http://cepl.gatech.edu/drupal/sites/default/files/EIPC_Final_01-24-13%5B1%5D.pdf

Comprehensive and integrated resource planning considers the potential for increases in energy efficiency to reduce the requirements for new generation and transmission investments. This study supports such planning efforts by developing robust estimates of the economically achievable potential for improving the energy-efficiency of homes, commercial buildings, and industrial plants located in the Eastern Interconnection. The approach of this study involves identifying a series of energy-efficiency policies and examining their impacts and cost-effectiveness using Georgia Tech's version of the National Energy Modeling System (GT-NEMS). The project emphasizes the impacts on electricity consumption, the levelized cost of policy-driven electricity savings, and distributive effects at the state and regional levels. Thirty-six states and the District of Columbia are covered by this study, and the time frame extends to 2035.

Brown, M. A., Baer, P., Cox, M., & Kim, Y. J. (2012). Evaluating the Risks of Alternative Energy Policies: A Case Study of Industrial Energy Efficiency. Working Paper #68. Atlanta, GA. Retrieved from http://www.spp.gatech.edu/aboutus/workingpapers/evaluating-risks-alternative-energy-policies-case-study-industrial-energy-efficiency

Numerous studies have shown the potential for U.S. manufacturing to cut its energy costs by installing more efficient equipment that offers competitive payback periods, but the realization of this potential is hindered by numerous obstacles. This paper evaluates seven federal policy options aimed at revitalizing U.S. manufacturing by improving its energy economics while also achieving environmental and energy reliability goals. Traditionally, policy analysts have examined the cost-effectiveness of energy policies using deterministic assumptions. When risk factors are introduced, they are typically examined using sensitivity analysis to focus on alternative assumptions about budgets, policy design, energy prices, and other such variables. In this paper we also explicitly model the stochastic nature of several key risk factors including future energy prices, damages from climate change, and the cost of criteria pollutants. Using these two approaches, each policy is "stress tested" to evaluate the likely range of private and social returns on investment. Overall we conclude that the societal cost-effectiveness of policies is generally more sensitive to alternative assumptions about damages from criteria pollutants and climate change compared with energy prices; however, risks also vary across policies based partly on the technologies they target. Future research needs to examine the macroeconomic consequences of the choice between a lethargic approach to energy waste and modernization in manufacturing versus a vigorous commitment to industrial energy productivity and innovation as characterized by the suite of policies described in this paper.

Brown, Marilyn A, Cox, M., & Baer, P. (2013). Reviving manufacturing with a federal cogeneration policy. *Energy Policy*, *52*, 264–276. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=83933257&site=eds-live&scope=site

> Improving the energy economics of manufacturing is essential to revitalizing the industrial base of advanced economies. This paper evaluates ex-ante a federal policy option aimed at promoting industrial cogeneration—the production of heat and electricity in a single energy-efficient process. Detailed analysis using the National Energy Modeling System (NEMS) and spreadsheet calculations suggest that industrial cogeneration could meet 18% of U.S. electricity requirements by 2035, compared with its current 8.9% market share. Substituting less efficient utility-scale power plants with cogeneration systems would produce numerous economic and environmental benefits, but would also create an assortment of losers and winners. Multiple perspectives to benefit/cost analysis are therefore valuable. Our results indicate that the federal cogeneration policy would be highly favorable to manufacturers and the public sector, cutting energy bills, generating billions of dollars in electricity sales, making producers more competitive, and reducing pollution. Most traditional utilities, on the other hand, would lose revenues unless their rate recovery procedures are adjusted to prevent the loss of profits due to customer owned generation and the erosion of utility sales. From a public policy perspective, deadweight losses would be introduced by market-distorting federal incentives (ranging annually from $30 to $150 million), but these losses are much smaller than the estimated net social benefits of the federal cogeneration policy.

Brown, Marilyn A, Gumerman, E., Sun, X., Sercy, K., & Kim, G. (2012). Myths and facts about electricity in the U.S. South. *Energy Policy*, *40*, 231–241. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=eih&AN=67701441&site=eds-live&scope=site

> This paper identifies six myths about clean electricity in the southern U.S. These myths are either propagated by the public at-large, shared within the environmental advocacy culture, or spread imperceptibly between policymakers. Using a widely accepted energy-economic modeling tool, we expose these myths as half-truths and the kind of conventional wisdom that constrains productive debate. In so doing, we identify new starting points for energy policy development. Climate change activists may be surprised to learn that it will take more than a national Renewable Electricity Standard or supportive energy efficiency policies to retire coal plants. Low-cost fossil generation enthusiasts may be surprised to learn that clean generation can save consumers money, even while meeting most demand growth over the next 20 years. This work surfaces the myths concealed in public perceptions and illustrates the positions of various stakeholders in this large U.S. region.

Brown, Marilyn A, Levine, M. D., Short, W., & Koomey, J. G. (2001). Scenarios for a clean energy future. *Energy Policy*, *29*(14), 1179–1196. doi:10.1016/S0301-4215(01)00066-0

This paper summarizes the results of a study—Scenarios for a Clean Energy Future—that assess how energy-efficient and clean energy technologies can address key energy and environmental challenges facing the US. A particular focus of this study is the energy, environmental, and economic impacts of different public policies and programs. Hundreds of technologies and approximately 50 policies are analyzed. The study concludes that policies exist that can significantly reduce oil dependence, air pollution, carbon emissions, and inefficiencies in energy production and end-use systems at essentially no net cost to the US economy. The most advanced scenario finds that by the year 2010, the US could bring its carbon dioxide emissions three-quarters of the way back to 1990 levels. The study also concludes that over time energy bill savings in these scenarios can pay for the investments needed to achieve these reductions in energy use and associated greenhouse gas emissions.

Coughlin, K., Shen, H., Chan, P., & Sturges, A. (2013). *Modeling the Capacity and Emissions Impacts of Reduced Electricity Demand. Part 1. Methodology and Preliminary Results.* Berkeley, CA.

Policies aimed at energy conservation and efficiency have broad environmental and economic impacts. Even if these impacts are relatively small, they may be significant compared to the cost of implementing the policy. Methodologies that quantify the marginal impacts of reduced demand for energy have an important role to play in developing accurate measures of both the benefits and costs of a given policy choice. This report presents a methodology for estimating the impacts of reduced demand for electricity on the electric power sector as a whole. The approach uses the National Energy Modeling System (NEMS), a mid-range energy forecast model developed and maintained by the U.S. Department of Energy, Energy Information Administration (EIA) (DOE EIA 2013). The methods and assumptions implemented in NEMS receive extensive exposure and 3 scrutiny with each publication of EIA’s annual forecast, the Annual Energy Outlook (AEO) (DOE EIA 2012a). Lawrence Berkeley National Lab (LBNL) has used NEMS to estimate the utility sector impact of the Department of Energy’s (DOE) Appliance and Equipment Standards Program for nearly a decade (DOE EERE 2013).1 The goal of the present study is to simplify the methods that have been developed for DOE, without any loss of accuracy, and to make the results available to a broader community.

Energy Information Administration. (2004). *Summary Impacts of Modeled Provisions of the 2003 Conference Energy Bill*. Washington, DC. Retrieved from http://www.eia.gov/oiaf/servicerpt/pceb/pdf/sroiaf%282004%2902.pdf

On February 2, 2004, Senator John Sununu requested that the Energy Information Administration (EIA) perform an assessment of the energy production, consumption, and price impacts of the Conference Energy Bill (CEB) of 2003 (also known as the Energy Policy Act of 2003). This report responds to that request by summarizing EIA’s analysis of the CEB provisions that can be modeled using the National Energy Modeling System (NEMS) and have the potential to affect energy consumption, supply, prices, and imports. The impacts of the CEB provisions analyzed are estimated by comparing the results of those provisions to the Reference Case of the Annual Energy Outlook 2004 (AEO2004).

Energy Information Administration. (2005). *Coal Transportation Rate Sensitivity Analysis* (pp. 1–15). Washington, DC. Retrieved from http://www.eia.gov/oiaf/analysispaper/stb/pdf/stb.pdf

On December 21, 2004, the Surface Transportation Board (STB) requested that the Energy Information Administration (EIA) analyze the impact of changes in coal transportation rates on projected levels of electric power sector energy use and emissions. Specifically, the STB requested an analysis of changes in national and regional coal consumption and emissions resulting from adjustments in railroad transportation rates for Wyoming's Powder River Basin (PRB) coal using the National Energy Modeling System (NEMS). However, because NEMS operates at a relatively aggregate regional level and does not represent the costs of transporting coal over specific rail lines, this analysis reports on the impacts of interregional changes in transportation rates from those used in the Annual Energy Outlook 2005 (AEO2005) reference case.

Energy Information Administration. (2005). *Impacts of Modeled Recommendations of the National Commission on Energy Policy*. Washington, DC. Retrieved from http://www.eia.gov/oiaf/servicerpt/bingaman/pdf/sroiaf(2005)02.pdf

On December 17, 2004, Senator Jeff Bingaman, ranking Minority Member of the U.S. Senate Committee on Energy and Natural Resources, requested that the Energy Information Administration (EIA) assess the impacts of the recommendations made by the National Commission on Energy Policy (NCEP), a nongovernmental privately funded entity, in its December 2004 report entitled Ending the Energy Stalemate: A Bipartisan Strategy to Meet America's Energy Challenges. This report provides EIA's analysis of those NCEP recommendations on energy supply, demand, and imports that could be simulated using the National Energy Modeling System (NEMS). The impacts of the NCEP recommendations analyzed are compared with results published by EIA in the Annual Energy Outlook 2005 (AEO2005).

Geisbrecht, R., & Dipietro, P. (2009). Evaluating options for US coal fired power plants in the face of uncertainties and greenhouse gas caps: The economics of refurbishing, retrofitting, and repowering. *Energy Procedia*, *1*(1), 4347–4354. doi:10.1016/j.egypro.2009.02.248

Facing a cost for emitting carbon dioxide, U.S. entities that own coal-fired power plants have a number of options to pursue as alternatives to retiring the plant and investing in a new one with lower carbon emissions. These include: (1) continuing to operate business as usual and obtaining emission allowances as needed, (2) switching to or cofiring low carbon fuels, (3) retrofitting with carbon capture and sequestration (CCS), (4) repowering with an advanced coal technology incorporating CCS, and (5) refurbishing to improve plant efficiency in combination with any of the previous options. Markets for refurbishing, retrofitting, and repowering were assessed using data bases of existing coal fired power plants along with the Energy Information Administration's (EIA) National Energy Modeling System (NEMS) code, which was modified to undertake an integrated analysis of how retrofit and repowering options would compete with other options for managing the fleet of coal fired power plants. Sensitivities with respect to key uncertainties are presented, including carbon values, natural gas prices, CCS incentives, and system-wide cost effectiveness of refurbishing in conjunction with retrofitting or repowering.

The indicated market for coal fired power plants that could be retrofitted with near commercial CCS technology under carbon cost scenarios ranging from 45 - 60 $/MTCO2e (metric ton CO2 equivalent) is on the order of 100 GW. A similar market is apparent for repowering, but with technologies that are as yet not commercialized. Below 30 $/MTCO2e, CCS technologies would not deploy without incentives. While refurbishing can extend the market for either retrofitting or repowering, its impact will depend on the extent to which efficiency as well as other cost related factors can be collectively upgraded.

Hadley, S. W. (2001). *The Potential for Energy Efficiency in the State of Iowa, ORNL/CON-481*. Oak Ridge, TN. Retrieved from http://www.ornl.gov/~webworks/cppr/y2001/rpt/112459.pdf

The purpose of this study was to do an initial estimate of the potential for energy savings in the state of Iowa. Several methods for determining savings were examined, including existing programs, surveys, savings calculators, and economic simulation. Each method has advantages and disadvantages, trading off between detail of information, accuracy of results, and scope. This paper concentrated on using economic simulation (the NEMS model (EIA 2000a)) to determine market potential for energy savings for the residential and commercial sectors. The results of surveys were used to calculate the economic potential for savings in the industrial sector.

Hadley, S. (2002). Energy Efficiency Potential in the State of Iowa. In American Council for an Energy-Efficient Economy (Ed.), *Proceedings of the ACEEE 2002 Summer Study on Energy Efficiency in Buildings*. Retrieved from http://aceee.org/proceedings-paper/ss02/panel09/paper11

The study is an estimate of the potential for energy savings in Iowa. It concentrated on using the National Energy Modeling System to determine the market potential for energy savings in the residential and commercial sectors. A base case using the Annual Energy Outlook 2000 was developed and sensitivities run based on the Clean Energy Futures study. For the industrial sector, the results of surveys on motor and drive system efficiency potentials were used to calculate the economic potential for savings. The major residential end-uses affected were space cooling (20% savings by 2020) and water heating (14%). The study did not include changes to the building shell (e.g., increased insulation) or residential lighting improvements. Nevertheless, the residential sector's market potential for electrical energy savings was calculated to be 5.3% of expected electrical use by 2020. In the commercial sector, the study considered voluntary market-based policies for some technologies. The most notable savings were in ventilation (12% savings by 2020), lighting (12%), refrigeration (7%), water heating (6%), and space heating (5%). The industrial survey of motor drive system improvements found that motor systems represent roughly 40% of electrical use within the industrial sector and that programs could improve their efficiency by 14%, saving 6% of total industrial electricity. Because of this study, the Iowa Utilities Board required utilities in the state to conduct detailed technology assessments to update their energy efficiency plans. Utilities redoubled their efforts to better use their existing programs, concentrating on performance contracting and new commercial designs.

Hadley, S. W. (2003). *The Potential for Energy Efficiency and Renewable Energy in North Carolina, ORNL/TM-2003/71*. Oak Ridge, TN. Retrieved from http://www.ornl.gov/~webworks/cppr/y2001/rpt/116643.pdf

The purpose of this study was to explore the potential for energy savings and renewable energy in the state of North Carolina. It concentrated on using economic simulation (the National Energy Modeling System or NEMS model) to determine the market potential for energy savings for the residential and commercial sectors and the potential penetration of renewable energy in all sectors.

Hadley, S., Erickson, D., Hernandez, J. L., & Thompson, S. (2004). “Future U.S. Energy Use for 2000-2025 as Computed with Temperatures from a Global Climate Prediction Model and Energy Demand Model”. In United States Association for Energy Economics (Ed.), *Proceedings of the 24th Annual North American Conference of the USAEE*. Cleveland, OH. Retrieved from http://www.iaee.org/documents/washington/Stan_Hadley.pdf

Hadley, S. W., Erickson III, D. J., & Hernandez, J. L. (2006). *Modeling U.S. Energy Use Changes with Global Climate Change, ORNL/TM-2006/524*. Oak Ridge, TN. Retrieved from http://apps.ornl.gov/~pts/prod/pubs/ldoc2494_ornl_degree_day_paper_final.pdf

Using a general circulation model of Earth climate (PCM-IBIS) to drive an energy use model (DD-NEMS), we calculated the energy use changes for each year from 2003-2025 for the nine U.S. Census regions. We used five scenarios: 1) a reference with no change in temperatures from the 1970-2003 average, 2) a gradual 1°F rise in temperature by 2025, 3) a gradual 3°F rise by 2025, 4) a climate simulation with low temperature response to CO_2 doubling in the atmosphere, and 5) a climate simulation with a more extreme response.

Hadley, S. W., Erickson, D. J., Hernandez, J. L., Broniak, C. T., & Blasing, T. J. (2006). Responses of energy use to climate change: A climate modeling study. *Geophysical Research Letters*, *33*(17), L17703. doi:10.1029/2006GL026652

> Using a general-circulation climate model to drive an energy-use model, we projected changes in USA energy-use and in corresponding fossil-fuel CO2 emissions through year 2025 for a low (1.2°C) and a high (3.4°C) temperature response to CO2 doubling. The low-ΔT scenario had a cumulative (2003–2025) energy increase of 1.09 quadrillion Btu (quads) for cooling/heating demand. Northeastern states had net energy reductions for cooling/heating over the entire period, but in most other regions energy increases for cooling outweighed energy decreases for heating. The high-ΔT scenario had significantly increased warming, especially in winter, so decreased heating needs led to a cumulative (2003–2025) heating/cooling energy decrease of 0.82 quads. In both scenarios, CO2 emissions increases from electricity generation outweighed CO2 emissions decreases from reduced heating needs. The results reveal the intricate energy-economy structure that must be considered in projecting consequences of climate warming for energy, economics, and fossil-fuel carbon emissions.

Hadley, S. W., & Short, W. (2001). Electricity sector analysis in the clean energy futures study. *Energy Policy*, *29*(14), 1285–1298. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bft&AN=513081528&site=eds-live&scope=site

> This paper examines the impact of policies to reduce carbon and other air emissions in the electric sector. The analysis is from a recent scenario development effort, Scenarios for a Clean Energy Future (CEF), by five National Laboratories. The CEF assesses how policies can be used to promote energy-efficient and clean energy technologies to address key energy and environmental challenges facing the United States. The impact of policies in the electric sector is evaluated using the CEF-NEMS model, which is derived from the National Energy Modeling System (NEMS) model developed by the DOE Energy Information Administration. The analysis shows that by 2020 under the policies analyzed, CO2 and other emissions can be substantially reduced by moving from coal to advanced gas combined cycle systems and renewable energy. Prices show little change and may drop due to decreased end-use demands.

Interlaboratory Working Group. (2000). *Scenarios for a Clean Energy Future, ORNL/CON-476 and LBNL-44029*. Oak Ridge, TN and Berkeley, CA. Retrieved from http://www.ornl.gov/sci/eere/cef/

> Smart public policies can significantly reduce not only carbon dioxide emissions, but also air pollution, petroleum dependence, and inefficiencies in energy production and use. A range of policies exists – including voluntary agreements; efficiency standards; increased research, development, and demonstration (RD&D); electric sector restructuring; and domestic carbon trading – that could move the United States a long way toward returning its carbon dioxide emissions to 1990 levels by 2010. Additional

means would be needed to achieve further reductions, such as international carbon trading and stronger domestic policies. The overall economic benefits of these policies appear to be comparable to their overall costs. The CEF policies could produce direct benefits, including energy savings, that exceed their direct costs (e.g., technology and policy investments). Indirect macroeconomic costs are in the same range as these net direct benefits. The CEF scenarios could produce important transition impacts and dislocations such as reduced coal and railroad employment; but at the same time, jobs in wind, biomass, energy efficiency, and other “green” industries could grow significantly. Uncertainties in the CEF assessment are unlikely to alter the overall conclusions. The policy and technology opportunities identified in the CEF are so abundant that they compete with each other to reduce carbon emissions. We would expect enough of them to be successful to achieve the results we claim. Furthermore, a broad range of technology options, with sufficient research, could provide additional solutions in the long run.

Jackson, J. (n.d.). Improving energy efficiency and smart grid program analysis with agent-based end-use forecasting models. *Energy Policy*, *38*(Large-scale wind power in electricity markets with Regular Papers), 3771–3780. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S030142151000159X&site=eds-live&scope=site

Electric utilities and regulators face difficult challenges evaluating new energy efficiency and smart grid programs prompted, in large part, by recent state and federal mandates and financial incentives. It is increasingly difficult to separate electricity use impacts of individual utility programs from the impacts of increasingly stringent appliance and building efficiency standards, increasing electricity prices, appliance manufacturer efficiency improvements, energy program interactions and other factors. This study reviews traditional approaches used to evaluate electric utility energy efficiency and smart-grid programs and presents an agent-based end-use modeling approach that resolves many of the shortcomings of traditional approaches. Data for a representative sample of utility customers in a Midwestern US utility are used to evaluate energy efficiency and smart grid program targets over a fifteen-year horizon. Model analysis indicates that a combination of the two least stringent efficiency and smart grid program scenarios provides peak hour reductions one-third greater than the most stringent smart grid program suggesting that reductions in peak demand requirements are more feasible when both efficiency and smart grid programs are considered together. Suggestions on transitioning from traditional end-use models to agent-based end-use models are provided.

Kydes, A. S. (2007). Impacts of a renewable portfolio generation standard on US energy markets. *Energy Policy*, *35*(2), 809–814. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=23449233&site=eds-live&scope=site

This paper analyzes the impacts of imposing a Federal 20 percent non-hydropower renewable generation portfolio standard (RPS) on US energy markets by 2020. The US currently has no RPS requirement although some state RPS regulations have been adopted but not uniformly enforced (see http://www.eia.doe.gov/oiaf/analysispaper/rps/index.html for a recent summary on RPSs in the US). The renewable portfolio standard (RPS) requires that 20 percent of the power sold must come from qualifying renewable facilities. The analysis of the 20 percent RPS was developed by using the December 2001 version of the National Energy Modeling System (NEMS) of the Energy Information Administration (EIA) and the assumptions and results of the Annual Energy Outlook 2002 (AEO2002) reference case. 2 [2] The outlook for natural gas wellhead prices has changed considerably in the Annual Energy Outlook 2006 (AEO2006) (). Natural gas prices in the AEO2004 are projected to remain well above $ 4.00 per mcf throughout the forecast, reaching $5.20 per mcf by 2025 in 2002 dollars. While higher natural gas prices are projected to make wind systems somewhat more attractive, the main impact of higher natural gas prices is to increase coal-fired capacity additions in the projection period. While the numerical results in the renewable portfolio analysis presented in this paper are expected to be somewhat different if AEO2006 are used, the trends and general conclusions are unlikely to be affected by the choice of baseline. A policy that requires a 20 percent non-hydro-electric RPS by 2020 appears to be effective in promoting the adoption of renewable generation technologies while also reducing emissions of nitrogen oxides by 6 percent, mercury by 4 percent and carbon dioxide by about 16.5 percent relative to the reference case in 2020. Electricity prices are expected to rise about 3 percent while the cost to the electric power industry could rise between 35 and 60 billion dollars (in year 2000 dollars in net present value terms).

Morris, C., & Patino-Echeverri, D. (2010). NEMS Modeling of East Coast Offshore Wind: Examining the Assumptions. Nicholas School of the Environment and Earth Sciences 2010-12-10. Retrieved from http://hdl.handle.net/10161/2872

The Energy Information Administration's (EIA) National Energy Modeling System (NEMS) is widely considered a credible source for domestic energy projections, and is frequently used to inform state and federal policy decisions. The model is used to publish the Annual Energy Outlook (AEO). The 2010 AEO publication suggest that offshore wind development along the eastern seaboard is predicted to grow very little over the next 25 years, yet there are currently over 2.5 GW of proposed offshore projects in this area, with interest growing steadily. This project seeks to determine whether NEMS modeling of offshore wind is based on accurate assumptions and on the current state of the industry. Key factors that shape NEMS results are examined. These factors include the shallow water offshore wind resource off the eastern seaboard, the overnight capital costs assumed by the model, and the way in which transmission and reliability costs associated with offshore wind are treated. The assumptions used by the EIA in their modeling were examined for each of these factors. Modeling scenarios were built to test the sensitivity of the results to changes in these assumptions. This method helped to identify which parameters weigh most heavily in how the model determines whether offshore wind will play a role in the near-term future of renewable energy production. Findings indicate that wind resource estimates are out-dated, but that the wind resource is not a constraint on the offshore development. Capital cost assumptions are in line with accepted industry values, and are the largest factor in how much offshore wind capacity is added over the next twenty-five years. This research suggests that capital costs must decrease by as much as 35% before offshore wind can out-compete other forms of renewable generation. Transmission and reliability cost effects are difficult to assess without more access to model data and the calculations it employs. Recommendations for improving the model include more transparency in assumptions and better documentation of model inputs and outputs.

Morrow, W. R., Gallagher, K. S., Collantes, G., & Lee, H. (2010). Analysis of policies to reduce oil consumption and greenhouse-gas emissions from the US transportation sector. *Energy Policy*, *38*(3), 1305–1320. doi:10.1016/j.enpol.2009.11.006

Even as the US debates an economy-wide CO2 cap-and-trade policy the transportation sector remains a significant oil security and climate change concern. Transportation alone consumes the majority of the US's imported oil and produces a third of total US Greenhouse-Gas (GHG) emissions. This study examines different sector-specific policy scenarios for reducing GHG emissions and oil consumption in the US transportation sector under economy-wide CO2 prices. The 2009 version of the Energy Information Administration's (EIA) National Energy Modeling System (NEMS), a general equilibrium model of US energy markets, enables quantitative estimates of the impact of economy-wide CO2 prices and various transportation-specific policy options. We analyze fuel taxes, continued increases in fuel economy standards, and purchase tax credits for new vehicle purchases, as well as the impacts of combining these policies. All policy scenarios modeled fail to meet the Obama administration's goal of reducing GHG emissions 14% below 2005 levels by 2020. Purchase tax credits are expensive and ineffective at reducing emissions, while the largest reductions in GHG emissions result from increasing the cost of driving, thereby damping growth in vehicle miles traveled.

Sun, X., Brown, M. A., Jackson, R., & Cox, M. (2012). Making Buildings Part of the Climate Solution by Enforcing Aggressive Commercial Building Codes. Atlanta, GA. Retrieved from http://www.spp.gatech.edu/aboutus/workingpapers/making-buildings-part-climate-solution-enforcing-aggressive-commercial-building-codes

This paper examines the impact of an aggressive commercial building codes policy in the United States. The policy would require both new construction and existing buildings that undergo major modifications to comply with higher building shell efficiency and more stringent equipment standards similar to the latest versions of the ASHRAE 90.1 Standard. Using the Georgia Tech version of the National Energy Modeling System (GT-NEMS), we estimate that the building codes policy could reduce the energy consumption of commercial buildings by 0.94 Quads in 2035, equal to 4% of the projected energy consumption of commercial buildings in that year. In the four targeted end-uses – space heating and cooling, water heating and lighting – estimated energy consumption would be 17%, 15%, 20% and 5% less than the Reference case forecast in 2035, respectively. The reduction of electricity and natural gas prices along with the consumption decline could save commercial consumers $12.8 billion in energy bills in 2035 and a cumulative $110 billion of bill savings between 2012 and 2035. The environmental benefits of the policy could also be significant. In 2035, 47 MMT of CO2 emissions could be avoided, generating cumulative benefits of $17 billion by 2035. The estimated benefit-cost ratio of this policy within the commercial sector is 1.4, with a resulting net benefit of $59 billion. The positive spillover effect of this policy would lead to an even higher economy-wide benefit-cost ratio.

Thomas, C. E. (2012). US marginal electricity grid mixes and EV greenhouse gas emissions. *International Journal of Hydrogen Energy*, *37*(24), 19231–19240. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN=83652361&site=eds-live&scope=site

Battery electric vehicles (BEVs) are often portrayed as “green,” implying negligible greenhouse gas (GHG) emissions. While BEVs are zero emission vehicles, the electrical power generators used to recharge vehicle batteries do emit copious GHGs. Some analysts have estimated the power plant GHG emissions due to charging EV batteries using the average electrical generator grid mix for a given region. However, the GHG protocol specifies that analysts should use the marginal grid mixes to accurately calculate GHG emissions from adding EVs to the vehicle fleet. This paper utilizes the marginal grid mixes for each electrical power region in the US, and calculates the vehicle-weighted average GHG emissions for the entire country. These calculations demonstrate that, on the average, each BEV that displaces a gasoline hybrid electric vehicle (HEV) will increase GHGs by more than 7% and each PHEV put in service will increase GHGs by an average of 10% compared to a gasoline HEV.

U.S. Energy Information Administration. (2010). *Energy Market and Economic Impacts of the American Power Act of 2010*. Washington, DC. Retrieved from http://www.eia.gov/oiaf/servicerpt/kgl/pdf/sroiaf%282010%2901.pdf

This report responds to a request to the U.S. Energy Information Administration (EIA) from Senators Kerry, Graham, and Lieberman for an analysis of the American Power Act of 2010 (APA).1 The APA, as released by Senators Kerry and Lieberman on May 12, 2010, regulates emissions of greenhouse gases through market-based mechanisms, efficiency programs, and other economic incentives.

U.S. Energy Information Administration. (2012). *Effect of Increased Natural Gas Exports on Domestic Energy Markets as requested by the Office of Fossil Energy*. Washington, DC. Retrieved from http://www.fossil.energy.gov/programs/gasregulation/authorizations/2011_applications/exhibits_11-128-LNG/15._EIA_Effects_of_increased_NG_exports_.pdf

This report responds to an August 2011 request from the Department of Energy’s Office of Fossil Energy (DOE/FE) for an analysis of “the impact of increased domestic natural gas demand, as exports.” Appendix A provides a copy of the DOE/FE request letter. Specifically, DOE/FE asked the U.S. Energy Information Administration (EIA) to assess how specified scenarios of increased natural gas exports could affect domestic energy markets, focusing on consumption, production, and prices.

U.S. Energy Information Administration. (2005). Impacts of Temperature Variation on Energy Demand in Buildings. *Issues In Focus*. Retrieved February 21, 2013, from http://www.eia.gov/oiaf/aeo/otheranalysis/aeo_2005analysispapers/vedb.html

> In the residential and commercial sectors, heating and cooling account for more than 40 percent of end-use energy demand. As a result, energy consumption in those sectors can vary significantly from year to year, depending on yearly average temperatures.

Worrell, E., & Price, L. (2001). Policy scenarios for energy efficiency improvement in industry. *Energy Policy*, *29*(14), 1223–1241. Retrieved from http://www.sciencedirect.com/science/article/pii/S0301421501000696

> We have investigated three policy scenarios, entailing different degrees of commitment to improve energy efficiency to address the energy, economic and environmental challenges faced by the US industry. The scenarios reflect alternative views of the urgency with which policymakers and the American people will view these challenges and the policies they will seek. The industry consumes about 37% of primary energy in the United States, and is expected to grow under business-as-usual conditions. The policy scenarios find energy efficiency improvements from 7% to 17% beyond business as usual by 2020 for the Moderate and Advanced scenarios, respectively. The study demonstrates that there are substantial potentials for further efficiency improvement in the industry. However, an integrated policy framework that accounts for the different characteristics of industrial sector decision-makers, technologies and sectors is needed to achieve these potentials.

Yu, X. (2008). Impacts Assessment of PHEV Charge Profiles on Generation Expansion Using National Energy Modeling System. *2008 IEEE POWER & ENERGY SOCIETY GENERAL MEETING, VOLS 1-11* (pp. 4857–4861). 345 E 47TH ST, NEW YORK, NY 10017 USA: IEEE.

> High penetration of plug-in hybrid electric Vehicles (PHEVs) in the next 5-10 years is plausible due to the benefits for both environments and end users. With the assumption of a high PHEV penetration, national energy modeling system (NEMS) software package is exploited to predict the growths of power generation plants. As an adjustable knob for the deregulated electricity market, the charging strategy of PHEVs is comparatively studied to gain a comprehensive picture of its impacts. Four typical daily charging strategies are investigated, which are: 1) uniform charging; 2) home-based charging; 3) off-peak charging; 4) vehicle-to-grid (V2G) charging. Electric capacity expansions by fuel types and preferred PHEV load profiles are characterized.

Cohen, J. A., Edwards, J. L., & Marnay, C. (2005). U.S. Regional Demand Forecasts Using NEMS and GIS. eScholarship, University of California 2005-07-01. Retrieved from http://www.escholarship.org/uc/item/1vk8t39b

The National Energy Modeling System (NEMS) is a multi-sector, integrated model of the U.S. energy system put out by the Department of Energy's Energy Information Administration. NEMS is used to produce the annual 20-year forecast of U.S. energy use aggregated to the nine- region census division level. The research objective was to disaggregate this regional energy forecast to the county level for select forecast years, for use in a more detailed and accurate regional analysis of energy usage across the U.S. The process of disaggregation using a geographic information system (GIS) was researched and a model was created utilizing available population forecasts and climate zone data. The model's primary purpose was to generate an energy demand forecast with greater spatial resolution than what is currently produced by NEMS, and to produce a flexible model that can be used repeatedly as an add-on to NEMS in which detailed analysis can be executed exogenously with results fed back into the NEMS data flow. The methods developed were then applied to the study data to obtain residential and commercial electricity demand forecasts. The model was subjected to comparative and statistical testing to assess predictive accuracy. Forecasts using this model were robust and accurate in slow-growing, temperate regions such as the Midwest and Mountain regions. Interestingly, however, the model performed with less accuracy in the Pacific and Northwest regions of the country where population growth was more active. In the future more refined methods will be necessary to improve the accuracy of these forecasts. The disaggregation method was written into a flexible tool within the ArcGIS environment which enables the user to output the results in five year intervals over the period 2000-2025. In addition, the outputs of this tool were used to develop a time-series simulation showing the temporal changes in electricity forecasts in terms of absolute, per capita, and density of demand.

Feedback

Ilić, M. D. (2011). The Challenge of IT-Enabled Policy Design for Sustainable Electric Energy Systems. *Power and Energy Society General Meeting, 2011 IEEE* (pp. 1–6). Pittsburgh, PA. Retrieved from http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6039895&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F6027502%2F6038815%2F06039895.pdf%3Farnumber%3D6039895

> This paper concerns complex interactions between the regulators, system operators/owners and the candidate investors in new technologies. It is proposed that an effective interactive framework should be put in place for decision-making that enables choice and it also meets the social objectives. Given the complexity of the electric energy systems this process can no longer be based on blue print rules supported by coarse scenario analysis. It requires, instead, Information Technology (IT)-enabled dynamic and interactive modeling and decision making by all industry stakeholders. In addition, the process requires a design of regulatory rights, rules and responsibilities (3Rs) for binding interactions that must be communicated between different industry participants. Moreover, it is suggested that the coarse National Energy Modeling System (NEMS) can no longer support the design of 3Rs. Instead, an Energy Temporal and Spatial Kit (ENTASK) is proposed to interactively link with the NEMS model that is well understood by the policy makers at present. An ENTASK-like tool is essential for facilitating public policy decision makers in assessing potential of diverse technologies while designing the 3Rs for the industry. The 3Rs must be binding as they have major financial, technical and economic implications. It is described how such an interactive IT-enabled decision making framework could support near- optimal investments in infrastructures needed to meet the social objectives. Perhaps most striking is the observation that such a framework facilitates novel ways of integrating while enabling choice.

Lacommare, K. H., Gumerman, E., Marnay, C., Chan, P., & Coughlin, K. (2004). *A new approach for modeling the peak utility impacts from a proposed CUAC standard*. Berkeley, CA. Retrieved from http://emp.lbl.gov/publications/new-approach-modeling-peak-utility-impacts-proposed-commerical-unitary-air-conditioni-0

> This report describes a new Berkeley Lab approach for modeling the likely peak electricity load reductions from proposed energy efficiency programs in the National Energy Modeling System (NEMS). This method is presented in the context of the commercial unitary air conditioning (CUAC) energy efficiency standards. A previous report investigating the residential central air conditioning (RCAC) load shapes in NEMS revealed that the peak reduction results were lower than expected. This effect was believed to be due in part to the presence of the squelch, a program algorithm designed to ensure changes in the system load over time are consistent with the input historic trend. The squelch applies a system load-scaling factor that scales any differences between the end-use bottom-up and system loads to maintain consistency with historic trends. To obtain more accurate peak reduction estimates, a new approach for modeling the impact of peaky end uses in NEMS-BT has been developed. The new approach decrements the system load directly, reducing the impact of the squelch on the final

results. This report also discusses a number of additional factors, in particular non-coincidence between end-use loads and system loads as represented within NEMS, and their impacts on the peak reductions calculated by NEMS. Using Berkeley Lab's new double-decrement approach reduces the conservation load factor (CLF) on an input load decrement from 25% down to 19% for a SEER 13 CUAC trial standard level, as seen in NEMS-BT output. About 4 GW more in peak capacity reduction results from this new approach as compared to Berkeley Lab's traditional end-use decrement approach, which relied solely on lowering end use energy consumption. The new method has been fully implemented and tested in the Annual Energy Outlook 2003 (AEO2003) version of NEMS and will routinely be applied to future versions. This capability is now available for use in future end- use efficiency or other policy analysis that requires accurate representation of time varying load reductions.

Lacommare, K. H., Marnay, C., Gumerman, E., Chan, P., Rosenquist, G., & Osborn, J. (2002). *Investigation of Residential Central Air Conditioning Load Shapes in NEMS*. Berkeley, CA. Retrieved from http://emp.lbl.gov/sites/all/files/REPORT%20lbnl%20-%2052235.pdf

This memo explains what Berkeley Lab has learned about how the residential central air-conditioning (CAC) end use is represented in the National Energy Modeling System (NEMS). NEMS is an energy model maintained by the Energy Information Administration (EIA) that is routinely used in analysis of energy efficiency standards for residential appliances. As part of analyzing utility and environmental impacts related to the federal rulemaking for residential CAC, lower-than-expected peak utility results prompted Berkeley Lab to investigate the input load shapes that characterize the peaky CAC end use and the submodule that treats load demand response. Investigations enabled a thorough understanding of the methodology by which hourly load profiles are input to the model and how the model is structured to respond to peak demand. Notably, it was discovered that NEMS was using an October-peaking load shape to represent residential space cooling, which suppressed peak effects to levels lower than expected. An apparent scaling down of the annual load within the load-demand submodule was found, another significant suppressor of the peak impacts. EIA promptly responded to Berkeley Lab's discoveries by updating numerous load shapes for the AEO2002 version of NEMS; EIA is still studying the scaling issue. As a result of this work, it was concluded that Berkeley Lab's customary end-use decrement approach was the most defensible way for Berkeley Lab to perform the recent CAC utility impact analysis. This approach was applied in conjunction with the updated AEO2002 load shapes to perform last year's published rulemaking analysis. Berkeley Lab experimented with several alternative approaches, including modifying the CAC efficiency level, but determined that these did not sufficiently improve the robustness of the method or results to warrant their implementation. Work in this area will continue in preparation for upcoming rulemakings for the other peak coincident end uses, commercial air conditioning and distribution transformers.

Short, W. (2007). *Regions in energy market models*. National Renewable Energy Laboratory, Golden, CO. Retrieved from http://purl.access.gpo.gov/GPO/LPS89682

> This report explores the different options for spatial resolution of an energy market model--and the advantages and disadvantages of models with fine spatial resolution. It examines different options for capturing spatial variations, considers the tradeoffs between them, and presents a few examples from one particular model that has been run at different levels of spatial resolution. A large number of national energy market models are currently used to do market and policy analysis. The most widely known in the United States is probably the National Energy Modeling System (NEMS), developed by the Department of Energy's (DOE) Energy Information Administration (EIA). NEMS is used primarily for developing the Annual Energy Outlook (EIA 2005). However, there are many other models...one striking fact about these models is that none of them use the same regional structure.

Steffes, D. W. (2005). Today is great, but what about next year and 2010? *World Oil*, *226*(12), 37–39. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=19270494&site=eds-live&scope=site

> In this article the author presents information on forecasting for the petroleum industry. This year, 2005, will go down as one of the best years ever for the petroleum producing industry. The author says that he started his own energy forecasting and planning firm in July 1973, right before what is commonly known as the first Arab Oil Embargo. The author says that he is not generally known as a consensus forecaster. He believes that the 1970 Interior Department study is the basis for today's Energy Information Administration NEMS model. the author says that for his assumptions, he has developed over the years what is called as Assumption Generator. He has categorized all assumptions into seven prime Influences: Social, Political, Economics, Ecological, Technology, Natural Resources and Geography. When a particular Influence changes, it affects the other six Influences; i.e., a change in oil economics makes more, or less, natural resources available. To forecast an individual Influence requires that the other six Influences be defined. A technology forecast only pertains to technical ability and science, while a technology assessment defines how the other six Influences will react to this technology change.

Energy Modeling Forum. (2011). *Energy Efficiency and Climate Change Mitigation* (Vol. I). Stanford, CA. Retrieved from http://emf.stanford.edu/files/pubs/22530/summary25.pdf

> This report summarizes the working group’s discussions of the modeling results on the role of energy efficiency improvements in global climate change mitigation strategies. The working group is planning an additional volume of individually contributed papers on most of the models in the study. This additional report will appear as a special issue of the Energy Journal later this year.

Comparative

Gabriel, S A, Rosendahl, K. E., Egging, R., Avetisyan, H. G., & Siddiqui, S. (2011). Cartelization in gas markets: Studying the potential for a "Gas OPEC". *Energy Economics*, *34*, 137–152. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edselp&AN=S0140988311001198&site=eds-live&scope=site

> Natural gas is increasingly important as a fuel for electric power generation as well as other uses due to its environmental advantage over other fossil fuels. Using the World Gas Model, a large-scale energy equilibrium system based on a complementarity formulation, this paper analyzes possible future gas cartels and their effects on gas markets in a number of regions across the world. In addition, scenarios related to lower transport costs and decreased unconventional gas supply in the United States are considered.

Lent, J. (2010). Statistics in a dynamic energy environment. *Chance*, *23*(4), 22. Retrieved from http://prx.library.gatech.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=55530550&site=eds-live&scope=site

> The article offers statistical information on energy policies issues made by the U.S. Energy Information Administration (EIA), which focuses on emissions trading and the costs and benefits on the use of light-duty diesel-fueled vehicles. It relates the National Energy Modeling System (NEMS) to the analysis of the international emissions trading system (ETS). Moreover, diesel consumption also raises the U.S. emission standards for nitrogen oxides and its price premium.

Morris, S. C., Goldstein, G. A., & Fthenakis, V. M. (2002). NEMS and MARKAL-MACRO Models for Energy-Environmental-Economic Analysis: A Comparison of the Electricity and Carbon Reduction Projections. *Environmental Modeling & Assessment*, *7*(3), 207. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=49880038&site=eds-live&scope=site

> The Annual Energy Outlook forecasts published by the United States Energy Information Administration (EIA) of the Department of Energy are based on results from the National Energy Modeling system (NEMS). This paper compares NEMS, which is used only in the U.S., with the U.S. version of MARKAL-MACRO (USMM) model, which is used in more than thirty-five countries. The two models predict similar results for the base 1999 US Annual Energy Outlook (AEO), but their results with carbon constraints are quite different. The differences of the models and those of their predictions are explained. USMM can be used to provide an alternative and complementary approach to projections of renewable technologies penetration and their potential in reducing carbon dioxide emissions in the USA.

Roop, J. M., & Dahowski, R. T. (2000). *Comparison of Bottom-Up and Top-Down Forecasts: Vision Industry Energy Forecasts with ITEMS and NEMS*. Richland, WA: Energy Systems Laboratory (http://esl.tamu.edu) 2010-06-09T18:04:23Z 2010-06-09T18:04:23Z 2000-04. Retrieved from http://hdl.handle.net/1969.1/90881

Comparisons are made of energy forecasts using results from the Industrial module of the National Energy Modeling System (NEMS) and an industrial economic-engineering model called the Industrial Technology and Energy Modeling System (ITEMS), a model developed for industrial energy analysis at the Pacific Northwest National Laboratory. Although the results are mixed, generally ITEMS show greater penetration of energy efficient technologies and thus lower energy use, even though the business as usual forecasts for ITEMS uses a higher discount rate than NEMS uses.

Sohn, I. (2010). Energy Forecasts to 2035: A Review of the 2010 Energy Outlook Report of the U.S. Department of Energy. *Foresight: The International Journal of Applied Forecasting*, (19), 44–46. Retrieved from http://proxygsu-grl1.galileo.usg.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=57757318&site=eds-live&scope=site

The article examines the 2010 energy forecasts released by the Energy Information Administration of the U.S. Department of Energy which focuses on long-term projections of energy demand, supply, and prices for the country's economy in 2035. The national modeling system (NEMS) of the EIA is the framework for long-term energy projections which correlates the demand for energy with gross domestic product (GDP). Details on the projections and alternative assumptions are discussed.

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